Using LCROSS as a Template for Future Impact Missions: Probing Sediment and Volatile Stratification K. M. Luchsinger[1], N. J. Chanover[1], [1]Department of Astronomy, New Mexico State University, Las Cruces, NM, USA. kluchsin@nmsu.edu

Introduction: In 2009, the Lunar CRater Observation and Sensing Satellite (LCROSS) mission impacted a Centaur rocket into Cabeus crater, a permanently shadowed crater near the lunar south pole. Observations of the resulting impact plume were used to detect water ice and even to characterize the concentration and stratification of water ice within the crater [1,2,3].

The LCROSS impact was a low cost addition to the Lunar Reconnaissance Orbiter (LRO) mission, and remains to this day the only mission to definitively detect water ice within permanently shadowed craters on the moon. Other missions are able to detect signatures that imply the presence of water ice, but these signatures could have other origins, such as blocky terrain or hydrogen-bearing molecules. The LCROSS impact lofted the lunar sediment above the crater wall, and therefore spectroscopic observations from the shepherding spacecraft were able to directly observe water ice absorption bands from the lofted material [2]. Ground-based observations and modeling were additionally able to characterize the properties of the lunar sediment [1,3]

Future Lunar Missions Future and current lunar missions could replicate the success of the LCROSS impact at additional locations. Current spacecraft already in orbit around the Moon or the Earth could, when decommissioned, impact into permanently shadowed craters as one final scientific experiment. Future missions could use the LCROSS mission as a template and use the rockets used to launch the spacecraft as the impactor.

Many permanently shadowed craters would be interesting targets, but some would be particularly intriguing. No permanently craters at the lunar north pole have ever definitively been shown to contain water ice, and therefore craters in the North pole with potential water ice signatures, such as Rozhdestvenskiy N and Whipple, would be excellent targets. Craters near Cabeus in the South Pole could constrain the variability of water ice concentration within a small geometric area, which could constrain the origin of the water ice. If we can identify craters with anomalous water ice signatures, we can begin to explore the formation and evolution history of the lunar polar water ice distribution, with the potential of using this history to better understand the origins and history of water on the Earth.

Small Body Missions Impact missions like LCROSS could also provide information about small bodies such as comets and asteroids. One upcoming impact mission to the binary asteroid Didymos, the Double Asteroid Impact Test (DART), will impact the DART spacecraft into the smaller of the binary pair, Didymos B. The resulting debris plume could be observed and modeled to characterize stratification within the impacted material, such as the depth of a bedrock layer or the depth of a surface finer material layer. Earth-based observations will characterize the effect of the impact on the orbit of the Didymos binary pair; however, these observations will not be able to resolve the impact plume. Therefore, the addition of a miniature cubesat camera, or another method of making in-situ observations, would improve the information return from the impact.

Conclusions The LCROSS impact delivered a vast quantity of information about the sediment within permanently shadowed lunar craters. Similar impact missions or lunar missions could use LCROSS as a template for what observations and techniques can provide useful information, such as volatile concentration or stratification within the impacted sediment.

This work was supported by NASA’s Lunar Data Analysis Program through grant number NNX15AP92G.

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